T H E   U N I V E R S I T Y   O F   M I C H I G A N

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and
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Final Report

CONCEPT AND DISCRIMINATION LEARNING BY APHASICS

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Introduction

Psychological studies of adult aphasics generally use patients who are hospitalized or out-patients who return regularly to a hospital or clinic for rehabilitation. In the case of hospitalized patients, there is frequently the problem that they have not stabilized in either their language or other intellectual behaviors. If they are long term institutional patients, there is the problem of morale and the general effects of institutional living on their emotional and intellectual state. The situation is more favorable when studies use out-patients, but there are other problems. Patients coming to the clinic or hospital for therapy may not have the time or composure to participate in a research project. Many are depressed and in a turmoil about their future, and are not in a frame of mind to take part in 'intellectual games'. It is often the lack of availability of subjects and the inconveniences, rather than lack of interest, which has resulted in a paucity of experimental studies of learning characteristics of aphasic subjects. Those studies which have been done, have usually been limited to data collected in one or two sessions. the few classic studies of problem solving, particularly those of Goldstein (1948), have become part of what is almost a mythology on the learning behavior of aphasics, and have been used to support a variety of different views on training and rehabilitation of this group of people.

The set of studies reported here, were obtained in a unique situation. Small groups of eight to sixteen aphasic patients at any one time were living and working together in an educational setting at the University of Michigan Speech Clinic. They were all stabilized patients, having recovered from the immediate complications of their illnesses. They were involved in a program of reeducation of language skills---which meant that they were regularly engaged in a type of cognitive effort. They lived in a situation of friendly cameraderie, and were experiencing in most cases, a first real attempt to return to a social world. Although they still suffered from feelings of depression and inadequacy, the serious problems of what to do with their lives were temporarily set aside, and their attitudes were more hopeful than they would have been in their own homes. They were expected to arise and dress each morning, and to participate in four or five hours of individual and group therapy. This arrangement which enabled seriously impaired aphasic patients to receive social and intellectual stimulation, made them appropriate subjects for these studies of concept learning.

The research described in this report was designed to investigate the information-handling behavior of adult aphasics. In particular the long-term goal was to devise techniques for the determination and evaluation of the learning capacity of the aphasic and to relate this knowledge to nonaphasic performance.

A single class of experiments designed to compare a variety of concepts and stimulus conditions within the same logical framework were used in the research. The group of experiments employed the study retained the structure of established concept learning techniques. Utilization of these techniques allowed for the quantification of the rate at which concepts were attained given varying levels of difficulty. As will be seen in the explication of the results of the research, the experiments revealed the strategies employed by the subjects as they attempted to solve the problems.

Background and Characteristics of the Experimental Group

A total of 87 different aphasics served as subjects in these concept learning studies. Of these, nine were from a Boston group, 6 from an Indiana group, and 72 were from The University of Michigan Speech Clinic. The 9 Boston subjects were from the Veteran's Hospital in that city. They were diagnosed as aphasic by Dr. N. Geschwind and his staff. The 6 Indiana subjects were diagnosed as aphasic by Dr. O. Taylor and his staff at the Speech Clinic of Indiana University. Complete background data were not obtained for the Indiana and Boston subjects.

Extensive information was available for the remaining 72 subjects from Michigan. In addition to the extensive statistical and clinical data in the patient's folder, members of the staff of the concept learning study had many opportunities to meet the aphasic patients informally. One member of the staff who ran many of the subjects in the experiments had also given standard psychological tests to each of the patients. The staff of speech therapists were available for interpretations of the language and therapy reports in the folders, as well as to give further information about the characteristics of each patient, including those relating to social and emotional adjustment.

Such obviously 'non scientific' information is particularly useful in preparing and setting the stage for studies which aim at a certain amount of experimental control, yet at the same time must deal with a language impaired group of subjects. Without this background information and without informal contacts with the aphasics, it would not have been possible to run them through a set of difficult tasks which, under normal conditions, they would have rejected outright.

A note on criteria used for admission to the aphasia rehabilitation program at the University of Michigan is relevant here. Aphasic subjects are referred to the Aphasia Division of the Speech Clinic from a variety of sources. The typical patient who applies to the program has already been diagnosed as aphasic by a physician, has recovered from the initial insult, has shown some motivation to improve his language status (or has a relative who feels he might be improved), and is able to take care of his own daily needs, such as dressing and bathing. The program is expensive, so that the family must have financial resources or must be enterprising enough to seek agency support.

Evaluation of each patient entering the Aphasia Division is made by a speech pathologist, an audiologist, and a clinical psychologist. Psychotic patients, patients without a clear cut aphasia of neurological origin, patients who are too weak or incapacitated to take part in a full therapy day, are not admitted. By these various siphoning techniques, the patient at the very bottom of the impairment scale (ie. bedridden, in a vegetative state) is not seen. At the opposite end an elimination process also occurs. Patients whose aphasic symptoms are so mild that they are able to hold down a normal job and interact in normal social situations, are not admitted to the program. The reason for this is purely practical---the therapy staff does not have an appropriate training program developed for this group.

Patients who are admitted to the therapy program have language problems ranging from very severe to mild, but even the mildest cases have enough of a deficit so that they cannot hold down a job or interact comfortably in most social situations. Except for a rare case, they are sufficiently damaged so that they never return to their former occupations. Many are no longer employable in any capacity.

As can be seen from the accompanying tables (Table 1), the experimental group was heavily weighted toward middle aged male victims of CVAs. Half of the group was hemiplegic. Educational background varied, but over half had some academic or trade training beyond the high school level.

Table 1. Background of Michigan Aphasics

Age	
Below 20	4
20-29	5
30-39	7
40-49	24
50-59	19
60-69	11
70-79	2
	72

Sex	
Male	50
Female	22
	72

Occupation	
Unskilled	1
Skilled	18
Office and Sales	13
Professional and Managerial	24
Armed Forces	1
Student	5
Housewife	10
	72

Education	
High School or Below	31
Training beyond High School but less than BA	13
BA or equivalent	16
Training beyond BA	12
	72

Medical Diagnosis	
CVA	61
Trauma	8
Tumor or Abscesses	3
	72

Visual Problems	
Visual Field Defect	10
Double Vision	1
Complete loss in one eye	2
No uncorrected defect	59
	72

Time Since Onset

Range-4months to ten years

Mean 17.38 SD 15.71

Motor Involvement	
Hemiplegia	35
Residual Weakness	24
No Significant Involvement	13
	72

Occupational background also varied, but there was a preponderance of skilled and professional workers.

In summary, the selection procedures were such as to exclude extreme cases from the rehabilitation program. There was also some selective factor operating so that the group tended to have a higher educational and occupational background than one would find in a unselected group of patients. What follows is a relatively detailed description of the 72 aphasic subjects tested at The University of Michigan.

Medical History. Beyond the general etiology (CVA, tumor, trauma), neurological data on these patients varied in completeness and specificity. Localization information varied from 'lesion in left hemisphere' to detailed information on locus of lesion. For this reason, no serious study could be made of the neurological history. Similarly, it was not possible to assess the effects of medication on the intellectual performance of the subjects. Medication data was not always recorded in the folders and many changes of medication, particularly the amount used, were constantly taking place. Moreover, the effects of these drugs on the intellectual performance are not completely known. It can safely be stated that most patients were on some type of medication, and many of these were on several types. It was commonplace for the CVA patients to be on anticoagulants. The 22 patients with a seizure history were on anti-convulsant drugs. An unknown number were on barbiturates or other tranquilizing drugs. Since the patients who participated in this set of studies were able to carry on their normal therapy schedule, those who were suffering particular problems of adjusting to medication, were eliminated. Clearly, without the benefit of drugs, many of the patients would not have been accessible for the study reported here.

Ten subjects had visual field defects. No separate study of these subjects was made. It was determined prior to the experiment, however, that they were able to make the necessary discriminations between the types of stimuli utilized in the study. One subject with double vision wore a patch on one eye.

Tests of Intellectual Function. The performance tests of Wechsler Adult Intelligence Scale were given to all aphasics on admission into the Speech Clinic. Where appropriate, portions of the verbal subtests were also used, but it was not feasible to convert responses into numerical scores.

Table 2 shows that 41 out of 72 subjects had a Performance IQ in the average range (91-109) or above, and only 9 subjects had scores in the defective range (below 80).

Table 2. Psychological Test Scores

Distribution of WAIS Test Scores (Perf. IQ)	
60-69	6
70-79	3
80-89	22
90-99	22
100-109	18
110-119	0
120-129	1
	72

Distribution of Raven Percentile Scores	
Above 95th percentile	6
90-94	3
75-89	5
50-74	21
26-49	12
11-25	9
6-10	4
0-5	8
no data	4
	72

WAIS Means and SDs of Aphasics in Concept Learning Experiment and of All Aphasic Patients Tested at the U. of M. Speech Clinic from 1964-1967 (in standard scores).

Subtest	Concept Learning Group		All U. of M. Patients	
	Mean	SD	Mean	SD
Picture Completion	8.56	2.14	8.28	2.46
Block Design	7.92	3.06	7.56	4.13
Object Assembly	7.23	2.79	7.05	3.00
Picture Arrangement	6.94	2.87	6.24	3.27
Digit Symbol	3.97	2.43	3.81	2.56
Performance IQ	90.78	12.29	89.60	14.07
Number of Patients	72		169	
Age	46.60	14.34	49.38	13.20

This is not to be interpreted as evidence that many of these aphasics are functioning in a normal manner. From clinical experience in administering this test, it is clear that regardless of numerical score, all aphasics show signs of impaired function. This can be inferred from the response time on some of the items, unexplainable failures in an otherwise good performance, unusual difficulties in getting started on a subtest, and so on. In many cases, the lowered score is purely a function of time, and the subject is able to do all of the problems if given additional time. From the above mentioned signs, and from the educational level of many of the subjects, we can infer that they are functioning below premorbid levels on these measures of nonverbal intellectual function.

The means and standard deviations for each of the Performance subtests and the Performance IQ are similar to those reported by a number of investigators (cf. Reitan, 1960). They also compare favorable with figures obtained from all 169 patients with aphasia who were seen at the University of Michigan Speech Clinic, over a four year period (Table 2). The slightly higher scores of the experimental group reflect the selection procedures already described. Performance on the subtest, Digit Symbol, shows the greatest impairment. This finding is consistent with many reports on test performance of a variety of brain damaged subjects and probably reflects the inability or inflexibility of these subjects in adapting to a new learning task. Alajouanine and Lhermitte (1962) report that a significant reduction in Wechsler performance test scores are found in about 25 percent of their aphasic patients. Further, Picture Arrangement and Digit Symbol are performed in a slow way.

The Raven Progressive Matrices (1938 edition) are another measure of nonverbal intellectual efficiency. This test was given to the aphasic subjects. Scores parallel the WAIS findings. Forty-seven of 68 subjects tested have scores in the average range (26th through 74th percentile) as defined in the test manual. As in the WAIS, impairment can often be detected clinically in those subjects who attain high as well as low scores. One such index is time required to complete the test. There are no time limit requirements for the test but the average time taken is about 45 minutes (see Table 2). It is not unusual for aphasics to require one and one half to two hours, necessititing a break at the half way mark.

<u>Tests of Language Function</u>. During the first two years of the study, all the subjects were given the Language Modalities Test for Aphasia (LMTA), and sometime after

the initial evaluation, the Minnesota Test for the Differential Diagnosis of Aphasia (MTDDA). These tests were administered by Dr. Tikofsky and his assistants. During the last year of the study, Miss J. Simonson administered the MTDDA, often making adaptations of parts of this test when clinically indicated. It was therefore not possible to do highly quantitative analysis of the test results. However, Dr. Tikofsky and Miss Simonson wrote extensive clinical reports based on the test results. From their reports it was possible to combine the language data and to adjust the differences. Table 3 shows all of the language data translated into the classification scheme of the LMTA. Because of the tenuousness of some of these classifications of patients, all patients were then divided into two groups, according to the schema outlined by Geschwind (1966). The fluent group includes the Broca type of aphasia, and includes the LMTA syntactic group as well as most of the LMTA global aphasics. The nonfluent group includes the classic Wernicke's aphasia and the anomic or amnesic aphasias. In the LMTA classification system, this would include semantic, jargon, and pragmatic aphasics.

Another classification, based on the language evaluations, was made by placing each of the following categories on a five point scale: listening, speaking, reading, and writing (see Table 3).

Table 3. Language Evaluation Data

Language Modalities Test for Aphasia Classification

Type	
Semantic	17
Syntactic	5
Mixed (semantic and syntactic)	14
Jargon (incl. Jargon with some semantic features)	13
Pragmatic	5
Global	18
	72

Reclassification according to Geschwind schema

Fluent aphasics	40
Non Fluent aphasics	32
	72

Severity of Aphasia broken down into four categories

	Speaking	Reading	Writing	Listening
Very Severe	12	15	4	7
Severe	19	24	26	18
Mod. Severe	21	19	26	34
Moderate	11	10	11	12
Mild	9	4	5	1
	72	72	72	72

Table 4 presents a set of correlations (product-moment) between the various test scores described above, and the language evaluations. The intercorrelations between the WAIS subtests are very similar to those published in the WAIS manual, they are all positive and significant (.01 level). Similarly, the Raven intercorrelations with the WAIS subtests are positive and significant. The language scales correlate with each other and with the psychological test scores, although the correlations are not as high as are those within the various psychological tests. From this table we can assume that here is a general severity factor which influences all of the behaviors sampled by the scales and tests, but that there is a considerable amount of variation in performance reflecting the different types of impairment caused by the brain damage. This general severity factor appears again in the concept learning results.

Instructions to the Subjects. There are special problems related to conducting experiments with a brain damaged, language impaired group. The primary one, of course, is getting a set of directions communicated to these subjects. In the experiments described on the next page, it was necessary to vary the time spent in

Table 4. Intercorrelations of Psychological Test Data and Language Classifications (n=72)

	D.S.	P.C.	B.D.	P.A.	O.A.	Perf. IQ	Raven	L.	S.	R.	W.
Dig. Sym.	---										
Pict. Comp.	.50	---									
Block Des.	.55	.50	---								
Pict. Arr.	.52	.48	.59	---							
Obj. Ass.	.41	.45	.64	.56	---						
Perf. IQ	.65	.58	.73	.68	.72	---					
Raven Percentile	.44	.66	.61	.49	.47	.72	---				
Listening	.50	.34	.33	.38	.17	.34	.37	---			
Speaking	.59	.26	.30	.36	.31	.42	.33	.61	---		
Reading	.46	.37	.44	.42	.41	.40	.34	.50	.55	---	
Writing	.46	.25	.28	.39	.36	.37	.24	.62	.66	.72	---

r of .27 or above is sign. at the .05 level
r of .35 or above is sign. at the .01 level

preparation, and the exact directions given to each subject. It was also necessary to establish for each individual, a reliable mode of response. The general outline of directions were as follows: (At no time were these instructions read or given in this exact fashion. They represent limits for the experimentor as to how much information he could give the subject. Sometimes the material was presented in words, sometimes by gestures, sometimes by example.)

> The purpose of this study is to find out how people solve problems. We will be working with pictures (words) like these (show complete set of 32 stimuli). All of these pictures are different. Some of the pictures will have one figure inside like this (point out for S) and some will have two figures like this (point out all variables). Some will be large and some will be small. Some will be dark inside, others will be light. Some will be circles inside, some will be triangles. Some will have circles outside, the others will have triangles. (For words, the five different letter positions were illustrated: first position S-C; 2nd position H-L; 3rd position O-A; 4th position, P-R; 5th position S-E).
>
> Now I am going to show you eight of the pictures (or four) with this machine. Some of the pictures will be called 'yes' and some will be called 'no'. Your job is to learn which pictures are 'yes' and 'which ones are 'no'. There is a rule which makes a picture 'yes' or 'no'. I want you to try to learn this rule. I will show you the same eight pictures over and over again until you have learned the rule. Then I will show you this deck and ask you to use the rule you have learned to tell me whether these pictures are

'yes' or 'no'. I will tell you for the first eight, whether the answer is 'yes' or 'no'. Then you will try. After each try, I will give you the correct answer. Remember to try to learn the rule. (Alternate instructions) Start off by guessing. I will tell you if your guess is correct. Sorting instructions were as follows: Now I will show you the cards in this deck one at a time. Your job is to use the rule and tell me if the picture is a 'yes' or a 'no'. I cannot tell you this time if you are correct or not.

A second type of problem of experimenting with this group of subjects has to do with the emotionality and extreme feelings of inadequacy which are frequently encountered. It was often necessary to explain the experiment several times during the learning series. Sometimes a considerable amount of time was needed to cajole, calm, counsel patients until they felt relaxed and ready to engage in the experiment. Neglect of these needs would not only violate standards for conducting experiments with human subjects, but would have resulted in incomplete and inadequate data. It is very characteristic of this group of patients to tune out of a situation which is unpleasant by saying or gesturing "I don't know" or, "I can't". Particularly after experiencing failure at a task, it was often difficult to get the subject to continue the following day. Inevitably, some of the patients gave up and could not be persuaded to continue. Other times, it was necessary to lose a session in order to save the patient for the remaining sessions of the experiment.

General Issues Relating to Experimental Design. It is customary in neuropsychological studies to design studies which relate some aspect of behavior to locus of lesion, to compare performance of left and right hemisphere brain damaged patients, to compare brain damaged patients with and without language disorders. One of the problems in such studies is obtaining accurate localization data. Particularly with patients with CVAs, the problem is compounded by the very likely possibility that there has been scattered damage to the central nervous system as a consequence of arteriosclerotic changes. The approach of the present investigation was to neglect such comparisons in favor of a more detailed study of learning characteristics of a group of patients whose primary problem is aphasia. This means that the findings will not necessarily point to unique characteristics of this population nor will they necessarily be direct consequences of the language deficits. They will be of use primarily because there is so little known about learning characteristics of aphasics---particularly the range and variations in performance which are found in this group.

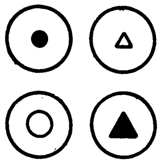
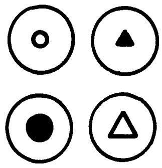
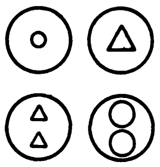
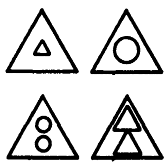
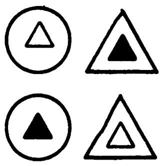
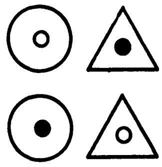
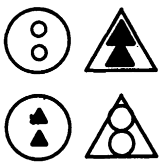
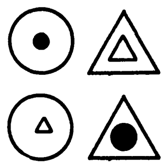
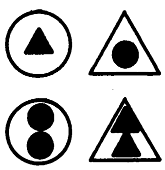
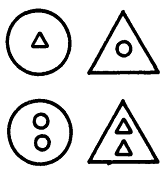
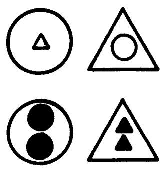
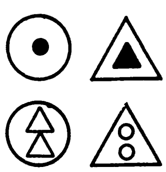
Nonaphasic Subjects. Normal subjects were obtained from the subject pool of undergraduates of the University of Michigan. They were all young and with no known neurological damage. Information from this group served only as a general guideline of what one may expect from a young, functioning, intelligent group of subjects.

Methods of Procedure: General Comments

Generation of stimuli for all tasks, whether Ss had to learn by rote or by rule, followed a systematic procedure. A master set of 32 nonverbal stimuli was constructed by taking all possible combinations of 5 dichotomous attributes: Number (1 or 2 forms), Size (large or small forms), Color (white or black forms), Form (circular or triangular) and Border (circular or triangular). Examples of subsets of stimuli are given in Table 5. A master set of 32 verbal stimuli was constructed from all possible combinations of pairs of letters in each of 5 letter positions: 1st: S or C, 2nd: H or L, 3rd: A or O, 4th: P or R, and 5th: E or S. The complete set of verbal stimuli is given in Table 6.

All nonverbal stimuli were quite abstract, but some were more easily identified by aphasic Ss than others, (cf. Experiment #6). On the other hand, 14 of the 32 verbal stimuli (Table 6) were common English words and were adequately defined by a group of some 30 normal Ss. Of the remaining words, 10 were obscure or rare English words with dictionary definitions, none of which were recognized by the normal Ss, and 8 were not to be found

Table 5. Examples of Subsets of Stimuli in Classification Tasks.

Stimulus Sets		*Variables	Rules	Constraint terms (in bits)	
YES Class	NO Class			Rel. Var.	Irrel. Var.
		C,-,F,-,S	No rule (rote task)	---	---
		-,B,F,N,S	Y:○border;N:△border	$\overline{BFNS}$ = 1.00	
		C,B,F,-,S	Y: large; N:small or Y: △form;N:○form	F:S = 1.00	---
		C,B,F,N,S	Y: two forms N: one form or Y: wh.Ⓢ or bl. ◬ N: bl.Ⓢ or wh.◬	$\overline{CFN}$=1.00	B:S = 1.00
		C,B,F,N,S	Y: black; N:white or Y: large; N:small	C:S = 1.00	$\overline{BFN}$ = 1.00
		C,B,F,N,S	Y: lge.Ⓢ or sm.◬ N: sm.Ⓢ or lge ◬ or Y: 1 wh. or 2 bl. N: 2 wh. or 1 bl.	$\overline{CBF}$=$\overline{BNS}$=$\overline{CFNS}$=1.00 $\overline{CBFNS}$=-1.00	

*C: Color; B: Border; F: Form; N: Number; S: Size. Levels are as shown.

Table 6. <u>The Verbal Stimuli</u>

share	chare
shars	chars
shape	chape
shaps	chaps
shore	chore
shope	chope
shops	chops
slare	clare
slars	clars
slape	clape
slaps	claps
slore	clore
slors	clors
slope	clope
slops	clops

in any dictionary. This latter situation provided the possibility of comparing common with rare words as stimuli which were otherwise completely comparable (cf. particularly Experiment #8).

A task was constructed by selecting a subset from the master set of stimuli which, when dichotomized into YES and NO response classes, would either keep the attributes or letter position entirely independent for a rote learning task, or would constrain one or more of them with the response classes so that a rule could be learned. In general, Ss were shown all of the subset of stimuli serially, which constituted a _trial_, and then given several such trials, each with a different order of the stimuli. A _task_ consisted of the several trials allowed within some time limit or that number required by the Ss to reach _criterion_ which was two completely correct trials.

In the construction of different kinds of tasks, some attributes or letter positions were intercorrelated. In others, they were not. Measures of constraint were used to calculate these relationships. When there was zero constraint, the task did not permit solution by rule and the stimuli had to be learned by rote learning. With one _bit_ of constraint, one rule was possible and it could either be a simple or a complex rule. With two _bits_ of constraint, two alternative simple or complex rules were possible in the task, or one simple and one complex might be available. No higher values of constraint were used in these tasks.

Since symmetric uncertainty analysis was used to construct and analyze the stimuli, response class relationships to the subsets were always symmetrical. For example, if the rule was a simple, or one-attribute rule, such as COLOR, the YES response class might be associated with _black_. In this case, the NO response class was always with _white_, the other category of the dichotomous attribute. For a complex rule which was composed of the two attributes of COLOR and FORM, the YES class might be associated with _black and circular or white and triangular_, and the NO class associated therefore with _white and circular or black and triangular_. In this case the rule involved two conjunctions and a disjunction. Another type of complex rule, less difficult than the above illustration is a standard conjunction where COLOR and FORM are associated and _black and circular_ would be YES, while NO would be associated with _white and triangular_. Disjunctions were not possible with this technique: _black or circular_, for example, could not be used by itself.

In the case of rote tasks, it was stated that no rule was possible. More accurately, a rule was always possible, but in the case of 4 stimuli, the rule involved all combinations of 2 attributes and therefore amounted to a description of each stimulus. Similarly, in the case of 8 stimuli, 3 attributes were necessary and merely described each stimulus. Such uniquely descriptive rules were also available when the task could be learned by a simpler rule, but, as will be seen below, it is highly improbable that such complex rules were used since rote tasks were much more difficult than corresponding rule tasks, however complicated the rule was.

Following a given maximum number of trials, or at the end of 2 completely correct trials, each S was asked to transfer the rule by sorting the master set of cards bearing the stimuli. Ss were instructed specifically to use the rule they had just used to sort the original stimuli, which were presented serially by slide projection. In either the learning or transfer task, Ss identified each stimulus from the master set as YES or NO, except when they were asked only to select from the master set that subset they used in learning from the slides, and not to identify each stimulus by its response class. In the case of rote tasks, Ss were asked first to select the subset of stimuli from the master set and then to identify its correct response class.

In the learning task, Ss were always given the correct response class after their response to each stimulus presentation, but were not informed whether they were correct or incorrect in the transfer task. In some experiments below, Ss were first shown the complete subset of stimuli and given the correct response class; in others, they were asked to guess from the outset. In the descriptions of experiments which follow, deviations from the above conditions will be explained, otherwise it may be assumed that the above conditions hold. Ordinarily, Ss worked on only 1 task per day, but in later experiments, 2 tasks per day were given.

Rules are abbreviated as follows: "C" stands for a COLOR rule where either black or white has been associated with the YES class and the other one with the NO class, "F" stands for FORM, "B" stands for BORDER, "N" stands for NUMBER, and "S" stands for SIZE. C-FB stands for the fact that two rules could be used, one simple and one complex: COLOR and FORM-BORDER, NS-CB stands for two complex rules: NUMBER and SIZE. Finally, CB stands for a single complex rule. Rote tasks are labelled ROTE.

A total of 14 different experiments were run during the course of the research. A general overview of the experiments and numbers of subjects participating in each is presented in Table 7. In the next section of this report, the specific purposes of each experiment will be outlined, stimuli will be described and labelled, presentation will be described if different from the standard stated above, and results regarding the effects of variables used in the experiment will be outlined. An overall set of conclusions will follow as a separate section. Many of the points covered in the final section are summarized in Carson, et al, (1968).

What follows is a detailed description of each of the 14 experiments carried out during the course of the research program. These descriptions follow the same format throughout. Reference to Table 7 (see page 29) gives an overview of the details for the experiments.

Table 7. <u>Description of the Learning Experiments</u>

	NUMBERS OF EXPERIMENTS:																
	Aphasics													Normals			
	1	2	3	4	5	6*	7	8**	9	10	11	12	13	4	9	12	14***
No. of Ss used	9	10	10	12	10	12	(9)	6	9	9	8	8	15	23	15	8	30
Tasks/S	12	10	8	10	2		(10)	20	20	8	8	4	10	10	20	6	
Type of stimulus																	
picture tasks	12	10	8	10	2		(10)		10	4	4	2	5	10	10	2	
word tasks										4	4	2	5			2	
common								10	5						5		
rare								10	5						5		
Type of Task																	
rote tasks	1	1	2	2	2		(4)	8	8	4	4	4		2	8	6	
rule tasks																	
simple	9		3				(6)	12	12	4	4		4		12		
complex	2	9	3	8									6	8			
Tasks w/1 rule	3		2				(6)	12	12	4	4		10		12		
Tasks w/2 rules	8	9	4	8										8			
Tasks w/4 stim			4		2		(10)	20	20	8		2			20	2	
Tasks w/8 stim.	12	10	4	10							8	2	10	10		2	
Tasks w/16 stim.																2	
Tasks w/16 sort					2			10	10	4	4	2	10		10	3	
Tasks w/32 sort	12	10	8	10			(10)	10	10	4	4	2		10	10	3	
Constant YES		8		7			(5)	10	10					7	10		
Constant NO		7		7			(5)	10	10					7	10		
Alternating		8		6			(10)	20	20					6	20		

*Stimulus difficulty judgment task (noncomparable); 16 normals used also

**Computer controlled (data not included in this analysis)

***Word definition task (noncomparable)

The Experiments

EXPERIMENT I

Introduction. The purposes of this first study were to examine preferences for specific attributes, to compare roughly the facility of learning rules when 2 simple rules, 1 simple rule and 1 complex rule, or 2 complex rules were required, to compare a rote task with a set of rule tasks after much practice on the learning situation had been given, and to learn about aphasics overall adjustment to the experimental situation. Nonverbal (pictorial) stimuli only were used.

Experimental Design.

a. Number of tasks: 11 rule, 1 rote.

b. Trials permitted: 19

c. Tasks used: (S-F, N-F, S-C), (S, N-F, C-FB), (S, N-CF, C), NC-SF, NC-FB, ROTE. Tasks in parentheses in Latin Squares, with each S getting a different order.

d. Number of stimuli: 8

e. Ss given 1 correct trial.

f. Transfer set size: 32 cards.

g. Identification required in transfer.

h. Number of Ss: 9

Results and Discussion. The attribute of color was preferred more often than any other and exceeded its expected use by about 50 percent. The other attributes were used about as often as expected and so their preferences were indistinguishable from one another. Moreover, when an incorrect rule was used in the transfer tasks, the sorting was far more often done by color than any other rule. This preference may have been an artifact for this group of Ss or for the specific experimental design because the use of color in later experiments did not appear to exceed expected usage to the same degree as in this experiment.

The comparison of a rote task with one involving one or two rules is a comparison of the constraint in the stimulus set: zero constraint gives a rote task, 1 bit of constraint gives a one-rule task, and 2 bits of constraint gives two rules. No S showed better learning of the rote task than learning of any rule task. However, when only one simple rule was available, the tasks were easier on the average than when two possible rules were available. By chance, it would appear easier to guess from the two rules than from only one, the probability of being correct being higher. But there is a perceptual factor of first working on one rule and then noticing that another may be possible so that when an S is not getting 100 percent correct, he can become confused that he may have another rule operating.

Ss adjusted quite well to the tasks, even though there were some rather difficult rules to learn and to transfer. In terms of the overall ease of the tasks, Ss appeared either to learn a rule or not to learn it in the 19 trials alloted to them. Judging from the trials to criterion, the two largest groups of learned tasks (40 percent) fell at 2 and 3 trials. Also a large group fell at 19 trials and did not reach criterion. In this sense, they either learned the rule easily or not at all. This all-or-none effect was shown by every S on some of these tasks. Of course, the complex rules were significantly more difficult to learn than the simple rules.

In the case of a rule involving FORM and BORDER (FB), it is possible to state the rule in a relational way: SAME SHAPE or DIFFERENT SHAPE. Moreover, the relationship was quite prominent and Ss commented about it on occasion. In the task where both C and FB could be used, 6 Ss used C and 2 Ss used FB, and it was the only rule used in the task with 2 complex rules (NC-FB). It would appear, therefore, as in previous experiments on normals, that aphasics can make use of relational rules to simplify their tasks. This conclusion is supported in the other experiments discussed below where this rule was used.

In overall performance, Ss got 75 rules in the 108 tasks tried, or about 69 percent of all tasks. Two Ss got 11 rules. A median of 9 rules was gotten by the group.

EXPERIMENT II

<u>Introduction</u>. The purposes of this study were to assess proficiency on a rote task without prior practice on rule tasks, to determine if more trials would permit Ss to learn the rules (to test the "all-or-none" effect noticed in Experiment I), and to test the effect of seeing the same stimulus in the same response class in several different tasks.

<u>Experimental Design</u>.

a. Number of tasks: 9 rules, 1 rote.

b. Trials permitted: 39

c. Tasks used: ROTE, followed by two orders of rule tasks (NB-CF, FB-SC, NS-CB, NB-SF, NF-SC, NS-CF, FB-NC, NF-CB, SB-CF).

d. Number of stimuli: 8

e. Ss given 1 correct trial.

f. Transfer set size: 32 cards.

g. Identification required to do transfer task.

h. Number of Ss: 10

Results and Discussion. Several Ss who were in the first study were also in this study along with some who were not and who had not previously had any practice on tasks of this type. Again, performance on the rote task was significantly poorer than on this set of complex rule tasks. Only one of the rule tasks was worked by as few Ss as the rote task.

With these complex rule tasks, the additional number of trials did not seem to help, and Ss again showed that either they were able to get the rule quite early or did not get it at all. There were some instances where rules were gotten after 19 trials and much sooner than 39 trials, but the larger group of cases was as before.

Attributes failed to show any preferences in their complex combinations, and it is assumed that Ss were able to adjust to the task of learning the complex rules without being biased by their preferences or by the ease of perception of the single attributes.

This conclusion does not hold when we consider the use of a specific stimulus in the same response class over several tasks. One stimulus was used in the YES class, one in the NO class and a third was alternated between the two classes serially and used for comparison.

Upon questioning after the experiment, many Ss said they had noticed the stimuli in the YES and NO classes which were the same, and no S could identify the alternating stimulus and did not recognize it when it was identified by the experimenter. Comparison of the alternating stimulus with both the YES and NO stimuli shows that Ss did significantly better on the latter two. This result may be interpreted by saying that Ss were attending to a simpler task than learning the rule and that this condition may have interfered with the more complex task. It is not just a matter that they learned the YES and NO stimuli more rapidly than the remainder, but that they actually did worse on the alternating stimulus than on the average performance on the other stimuli in the specific response class with the alternating stimulus. Nonaphasics did not show this effect as summarized in EXP. IV below.

In overall performance, Ss got 44 rules in the 97 tasks tried, or about 45 percent. Two Ss got all 10 rules, two Ss got no rules and the group showed a median of 6 rules acquired.

EXPERIMENT III

Introduction. The purposes of this study were to study serial learning by giving tasks in a special order from easy to difficult and to examine the effect of size of stimulus set on both rule and rote tasks (memory load).

Experimental Design.

a. Number of tasks: 8 per subject (total used: 14).

b. Trials permitted: 19

c. Tasks used: ROTE 4, ROTE 8, S8, F4, N4, B-N4, SF-NB4, NS-FB4, SB-NF4, SF-NB8, NS-FB8, SB-NF8. Order arranged from simple to difficult.

d. Number of stimuli: 4 and 8.

e. Ss given 1 correct trial.

f. Transfer set size: 32 cards.

g. Identification required in transfer.

h. Number of Ss: 10

Results and Discussion. The effect of learning simple rules and then progressing with improvement to more complex rules did not appear. Ss appeared to have adjusted to the general nature of the tasks and the experimental conditions quite early and the effects of the actual difficulty of the task showed as easier or more difficult tasks. In short, there was little transfer of any specific strategies from the easier, simple rule tasks, to the more difficult, complex rule tasks. Moreover, there was no transfer to the rote task using 8 stimuli. Since the rote task using 4 stimuli appeared first for all Ss, no transfer could be measured on it.

In comparing the rote and rule tasks using 4 and 8 stimuli, a significant interaction is observed: as before, 8 stimulus rote tasks are more difficult than are 4 stimulus rule tasks. A simple sampling hypothesis accounts for this difference, when we consider that there are about the same number of items to sort among in the 4 stimulus rote tasks than in the 4 stimulus rule tasks: 4 unique stimuli in the rote task and 5 rules (an average of 2.5) in the rule task. But in the 8 stimulus task, there are still the same number of rules but now the number of stimuli in the rote task has increased to 8, increasing the memory load on the Ss. In later experiments, this result holds: that learning of a rote task is about as easy as learning a rule if the number of stimuli are reduced. This same conclusion holds for normals as well as for aphasics.

In overall performance, Ss got 46 rules in the 78 tasks tried, or about 59 percent of all tasks. No S got fewer than 50 percent of the 8 tasks and no S got all of them. The group median was 5 tasks gotten.

EXPERIMENT IV

Introduction. The purposes of this study were to compare aphasic and normal performance on a set of complex rules and a pair of rote learning tasks, and to study the effects of using the same stimulus in the same response classes in different rule and rote tasks.

Experimental Design.

a. Number of tasks: 10

b. Trials permitted: 19

c. Tasks used: 6 rule tasks were Latin-Squared, preceded and followed by 1 rule and 1 rote task. (Rote 1, SB-CF, NS-CB, NB-SF, NF-SC, FB-NC, NF-CB, FB-SC, Rote 2).

d. Number of stimuli: 8

e. Ss given one correct trial.

f. Transfer set size: 32.

g. Identification required in transfer.

h. Number of Ss: 12 aphasics; 23 normals.

Results and Discussion. The Effects of the constant stimuli when compared with the alternating stimuli were the same for the aphasics in this study as they were in the earlier study. However, normals did not show the same effect. Instead of showing diverging learning, normals showed that while they performed better overall on the non-alternating stimuli, their performance on the two types of constant stimuli converged: they got better on the alternating stimulus relative to the nonalternating stimuli. In short, it appeared that they were able to take this less complex task in their stride, but it more seriously affected aphasic performance. Normal subjects' awareness of the alternating stimulus was the same as the aphasics, and they only noticed the constant stimuli of the same response classes.

In general, normal performance exceeded that of aphasics, however, normals were affected in the same ways as were aphasics in that the rote stimuli were significantly harder for them to learn than were the rule stimuli. In overall performance, aphasic Ss got 21 rules in the 96 tasks, or about 22 percent, with no S getting all 10 tasks, and two Ss getting none of them. Group median was 2 tasks gotten. Normal performance was 171 rules in the 207 tasks, or about 82 percent of the tasks tried. No normals got all of the tasks nor did any get no tasks at all. In a rough comparison, aphasics do about as well on simple rules and small stimulus sets as nonaphasics do on complex rules and larger stimulus sets.

EXPERIMENT V

Introduction. The purposes of this study were to add more comparison information on rote tasks using 4 stimuli, to examine the effect on performance of continued practice on rote learning well beyond criterion, and to study the effect of interrupting learning with a transfer task.

Experimental Design.

a. Number of tasks: 2.

b. Trials permitted: 40 (20 for each sort).

c. Tasks used: 2 ROTE tasks, order reversed for different Ss, picture stimuli.

d. Number of stimuli: 4.

e. Ss given one correct trial.

f. Transfer set size: 16.

g. Identification required in transfer.

h. Number of Ss: 10.

i. Both tasks given on same day.

Results and Discussion. All but one S showed excellent performance in rote learning with these sets of 4 picture stimuli. The data from this study are entirely comparable with other rote and rule learning data on 4- and 8-stimulus sets from other studies.

Of particular interest is the potential interference of interrupting practice with a transfer task and following this task with extended practice and a second transfer task. In some instances where Ss learned stimuli to criterion in a rule task, they were unable to transfer adequately to sorting a set of stimuli into the proper response classes. Also, it was reported earlier that in a few cases, Ss performed correctly in the transfer task, and in fact they were still making errors on the last learning trial given them.

It appears, therefore, that some Ss encountering some tasks treated transfer and learning tasks as almost two completely different problems, or at least were not using the same strategies and learning in both tasks. This result was obtained with 8-stimulus tasks.

One possibility is that the rules or stimuli had been precariously learned to criterion without a strong internal verbal representation of them so that when the transfer task was presented, the materials learned could not be appropriately attached to the stimuli in the apparently new task. This result could still obtain even though Ss practiced both pairs of tasks several times.

In these rote tasks using 4 stimuli, Ss appeared to have no trouble in continuing high level performance in the learning task whether or not they had been able to transfer correctly. Therefore, capacity of Ss was not overtaxed with 4 stimuli so that the interrupting transfer task interfered with their learning performance. Moreover, on the second transfer task, some, but not all Ss who failed to transfer correctly the first time, transferred correctly the second.

By comparing these results with those from 8-stimulus tasks, we may conclude that if the task does not present an overload situation for the aphasic, little interference from interruptions will be observed, and he may even learn relationships between two tasks that he had not previously learned.

EXPERIMENT VI

Introduction. The purposes of this study were to obtain judgment of relative ease of remembering each of the master set of 32 picture stimuli in order to equate stimuli on this factor when they were repeated from task to task in constant card experiments. Normals were used for this test, but it was decided to get aphasic judgments also to test the agreement between the two groups and to find out if aphasics could consistently give this kind of judgment.

Experimental Design.

a. Number of tasks: 3.

b. Trials permitted: NA.

c. Tasks used: 2 pair comparison tasks using 31 pairs each and 1 sorting task where all 32 stimuli were sorted into groups by their relative complexity.

d. Number of stimuli: NA.

e. Correctness: NA.

f. Transfer: NA.

g. Identification: NA.

h. Number of Ss: 12 aphasics; 16 normals.

Results and Discussion. The method was to obtain normal and aphasic judgments on "relative ease of remembering" each of the master set of 32 stimuli by pair comparison. Sixteen booklets of 31 randomly selected pairs were constructed and each S, normals and aphasics alike, judged 4 of the booklets each so that each S did not see all possible pairs. Data from all 16 normals and from 8 of the 12 aphasics was used. Agreement was so high between the two groups that the data were combined in balancing for the variable of ease of remembering on constant stimulus experiments where some stimuli were repeated from task to task over the tasks in the study. Rank-order correlations for the two groups between the ordering obtained on the pair comparison and the complexity sorting tasks were high and negative for both groups, so the pair comparison information was used for choosing stimuli in later studies. Normals had no trouble in either task and their results will not be discussed further.

Of interest here is the performance of the aphasics on these judgmental and ordering tasks. The 8 Ss who were able to perform in the tasks demonstrated that they understood the instructions and had no difficulty in either task. Some judgments took longer than others, but no judgment exceeded 30 seconds. Four other Ss were not able to perform the pair comparison task, which was always given first, either because they failed to understand the instructions by not responding with a choice, or because they could not reach a decision within 60 seconds, the time allotted for a single pair comparison. Mean decision time was just over 15 seconds, and therefore the average time for each of the two sessions of 62 comparisons was just over 15 minutes.

Instructions for the complexity sorting task asked that the 32 stimuli be sorted into not fewer than 4 piles of decreasing complexity nor more than 8. Aphasics were also able to understand and act according to these instructions, performing the entire sorting task in an average of 10 minutes after the second pair comparison task. Half of the subjects used fewer than 6 piles and the other half used more than 6, with 4, 7, and 8 piles being used by 2Ss each. Only 1 S on questioning after the task stated that he had difficulty with sorting according to the idea of complexity.

Judgments on individual stimuli for both groups ranged from 95 percent choices for the most easy to remember stimulus to 32 percent for the least easy to remember stimulus. Stimuli which were chosen for YES, NO, and alternating stimuli in experiments were in the middle to high range of ease of remembering.

EXPERIMENT VII

Introduction. The purposes and design of this study were identical to those of Experiment IX (infra), except that a computer was used ot present stimuli and to record responses and give feedback to Ss. Due to equipment malfunctioning not detected before analysis, the data from this study were not considered reliable and therefore will not be covered in this report.

EXPERIMENT VIII

Introduction. The purposes of this study were to examine verbal stimuli using letter positions as attributes, to compare common and rare words as they affect the learning of stimuli, compare rote with rule learning with this set of stimuli, and to examine the use of repeated stimuli using verbal materials.

Experimental Design.

a. Number of tasks: 20.

b. Trials permitted: 20.

c. Tasks used: 8 ROTE tasks; 12 RULE tasks, 4 each with 1st, 2nd and 3rd letter positions as simple rules. Order: 2 ROTE tasks, 6 RULE tasks in different orders for constant stimuli, 2 ROTE tasks; same order of tasks using rare words. Half of Ss saw rare words first, half saw common words first.

d. Number of stimuli: 4.

e. No correct traisl given.

f. Transfer set size: 16 cards.

g. Identification required in transfer.

h. Number of Ss: 6.

i. Ss in this study were run at the Speech Clinic of Indiana University.

Results and Discussion. Although complete test data were not obtained from this group of subjects, the language reports indicated that they were comparable to the University of Michigan sample. Therefore, the results from their rule learning tasks will be compared directly according to the variables used and not according to the group of Ss.

The most salient result concerns rote vs. rule learning. In earlier studies (Exps. IV and V) it was pointed out that aphasics showed little difficulty with rote tasks using sets of 4 nonverbal stimuli. In a direct comparison across all other variables in this study, using verbal stimuli, rule tasks were very much easier than comparable rote tasks. Among the group of tasks using common words, 29 percent of the rote and 64 percent of the rule tasks were learned. Among tasks using rare words, 22 percent of the rote and 63 percent of the rule tasks were learned. All word stimuli were easily pronounced by normals, and were pronounced for aphasic Ss at the beginning of the experiment. They should have been equivalent in terms of clues for memorizing to the nonverbal stimuli whose salient features had to be described by several verbal terms. However, all the words were quite similar in physical configuration, so the feature of their distinctive pronunciation was the main clue to their differences. Apparently aphasics were not able to use this kind of coding system well enough to distinguish the stimuli for the rote tasks, but they were able to use the letter positions to distinguish different letters and attach them to the correct response classes. Since the number of Ss in this experiment is small and may deviate significantly from other small groups of patients, this conclusion must be made as tentative even though statistical significance is quite high. Nevertheless, results from Exp. IX, infra, agrees with these preliminary findings.

There were no significant differences between performance on common and rare words, although only 45 percent of the tasks using rare words were learned as compared with 50 percent of the tasks using common words. The main part of this difference came from the difference between the two sets of rote tasks in the interaction, but the interaction was also not significant. This result is quite acceptable if we considre that the tasks of rote and rule learning were not directly related to the kinds of stimuli given, ie., the same kinds of performance using the same parts of the stimuli was required for both tasks. In this sense, the task could be divorced from the kind of stimulus material if the aphasic Ss chose to use the most appropriate strategy. Apparently they did, and little interference from either type of word, separately from the fact that they were verbal stimuli, was shown.

In the construction of these tasks, a special arrangement was used to set up repeated stimuli. For half of the Ss, the first 5 tasks had a constant YES stimulus and the second 5 tasks had the same stimulus changed to NO. For the other Ss, the order was changed so that the same stimulus became an alternating stimulus throughout the 10 tasks. There was no difference in overall performance between these two groups, although Ss with the repeated stimulus showed the expected result of learning and maintaining a higher percent correct on the repeated stimulus up to the 6th task when it was changed, and then quickly improving from the 7th and later tasks which indicated that they did recognize the stimulus from taskto task and were able to shift set on this simple recognition task embedded in the more complex rule and rote tasks. The other group showed no better than average performance on the alternating stimulus. Neither group was questioned after the experiment to find out if they had in fact recognized the card, so all the arguments here are statistical.

In overall performance, aphasic Ss got 55 out of 115 tasks, or about 48 percent of those tried. One S got 16 out of 20 tasks and one S got none. A median of 13 tasks was gotten by the group.

EXPERIMENT IX

Introduction. The purposes of this study were to compare verbal with nonverbal stimuli, to compare rote with rule learning on these kinds of materials, to compare the effectiveness of different sized transfer sets on both rote and rule tasks using verbal and nonverbal stimuli, and to assess the effect of repeated stimuli on learning.

Experimental Design.

a. Number of tasks: 20.

b. Trials permitted: 20.

c. Tasks used: 8 ROTE tasks; 12 RULE tasks with single-attribute rules. Orders same as in Exp. VIII with half of the Ss seeing words first and half seeing pictures first.

d. Number of stimuli: 4.

e. No correct trials given.

f. Transfer set size: 16 or 32 cards.

g. Identification required in transfer.

h. Number of Ss: 9 aphasics; 15 normals.

i. Aphasic Ss in this study were run at Boston Veterans Administration Hospital. Normals were undergraduate volunteers, run at Michigan. Aphasics worked on all 20 tasks over a 2 week period; normals worked on only 10 tasks during a 1 week period. The aphasic patients in this study were not engaged in the same intensive speech rehabilitation program at those at the University of Michigan. Moreover, only sketchy background information was available on these patients, even though that which was available put them in a class that was comparable to the other groups run in these studies. The comparative use of these subjects is made on the similarity of results to the Michigan population used in the very similar Exps. X and XI, infra.

Results and Discussion. Verbal and nonverbal sets of stimulus materials made no significant difference and aphasics performed about the same on each type, getting 41 percent of the nonverbal tasks and 47 percent of the verbal tasks. For the same reasons that common and rare words had no effect on aphasics' learning in the previous study, we should expect that verbal and nonverbal materials would show no differences in behavior also. The task at hand did not make direct use of the differences in the stimulus materials for learning and the aphasics were able to overlook these differences and concentrate on the learning tasks. The same effect among the normal Ss was observed, but the fact that they made such high scores on this set of tasks---96 percent of the tasks were gotten---that no differences of any kind were analyzable. Although verbal and nonverbal materials showed no differences, they did interact with transfer set size and with rote and rule tasks.

Repeated stimuli gave the same results as they did in Exp. VIII with the effect not being quite as pronounced. Again there were significant differences between constant YES or NO stimuli and alternating stimuli, but the effect of changing from YES to NO with the same stimulus at task 6 was not significant. This effect was the same for both verbal and nonverbal stimuli.

Overall differences between rote and rule tasks were significant with 55 percent of the rule tasks and 27 percent of the rote tasks gotten. However, in interaction with verbal and nonverbal materials, it is clear that for these 4 stimulus sets there was no difference between rote and rule tasks on the nonverbal materials --rote: 39

percent, rule: 42 percent---and that the difference between these tasks for verbal material was significant---rote 15 percent, rule: 68 percent. These results agree completely with Exps. IV, V, and VIII where 4 stimulus sets of verbal and nonverbal stimuli were used. Again the same reasons stated in Exp. VIII are given here to account for this result.

Since Ss were permitted to transfer what they learned to the transfer sorting task using different sized master sets, the actual number of correct transfers relative to the total number of tasks given was used, even though the S might not have learned the rule or rote task to criterion in the learning session. In some cases, an S might not have had time to finish the transfer task, or might have missed the entire learning and transfer task, but these instances were few and amounted to less than 3 percent of all cases of Ss tasks. In assessing the results of the transfer tasks, percentages refer to the total number of rote and rule tasks given.

In the interaction between transfer set size and verbal and nonverbal stimuli, 32 stimulus transfer sets were about equal in difficulty---verbal: 60 percent, nonverbal: 72 percent, but 16 stimulus transfer sets were much easier for verbal (34 percent) than for nonverbal (12 percent) materials. Apparently the larger sets were sufficiently easier for the Ss than they were insensitive to the effects of type of material, but as the transfer task became harder with the smaller set, it became more difficult to transfer with the nonverbal material than with the verbal material. Again Ss may not have coded the stimuli or rules verbally well enough to permit the transfer and this coding was interfered with by the nonverbal stimuli more than with the verbal. Overall differences between 16 stimulus sets (23 percent) and 32 stimulus sets (65 percent) were significant.

Taken together with the effect of verbal and nonverbal materials on rote and rule tasks, there is an inconsistency in the results of transfer set size. On the basis of probabilities of success, when stimulus sets are small enough not to create an overload on memory, there should be no difference between rote and rule tasks in ability to learn and transfer the learning. However, in any case of different kinds of stimuli, the probability of success should be higher with smaller than with larger transfer sets since with a constant number of stimuli, more of the smaller set are familiar to Ss. Therefore, there is a significant 3-way interaction here between kind of learning material, type of task and size of transfer set, given that the original learning set is held constant.

This 3-way interaction is most easily stated in the following manner. With aphasic Ss, learning by rote or by rule a number of stimuli which do not overload their capacities, such as with pictorial, or nonverbal materials, they find rote and rule learning tasks about equal but have difficulty remembering which variables have been eliminated in the smaller transfer set. This effect is a result of difference in appearance of the stimuli in the smaller set with those that are seen in the learning set not being verbally coded by Ss and thus interfering with memory. This effect does not appear with the verbal stimuli because they are all similar in appearance and Ss can attend to the single variable they have learned. Therefore, the rule tasks become much easier than the rote tasks because they are not confused by different appearances, only by being able to code the verbal stimuli by something distinctive such as pronunciation. Normals show none of these difficulties in tasks which are all easy for them.

In overall performance, aphasics got 45 out of 103 tasks, or about 44 percent of all tasks tried. One S got 17 of the 20 tasks and 1 S got none of them. The median number of tasks was 6 for the group.

EXPERIMENT X

Introduction. The purposes of this study were to compare verbal with nonverbal stimuli, to compare rote with rule learning, to compare two sizes of transfer sets, all points in the same fashion as Exp. 9, except that the effects of mixing alternately verbal and nonverbal tasks were also assessed.

Experimental Design.

a. Number of tasks: 8.

b. Trials permitted: 20.

c. Tasks used: 4 ROTE tasks; 4 RULE tasks with single-attribute rules using both verbal and nonverbal appeared in all 8 positions with equal frequency and were alternated.

d. Number of stimuli: 4.

e. No correct trials given.

f. Transfer set size: 16 or 32 cards.

g. Identification required in transfer.

h. Number of Ss: 8.

i. Number of tasks per session: 2.

Results and Discussion. Results in this study using Michigna Speech Clinic aphasics were entirely comparable to those of Exp. IX in all the main effects. However, some of the interactions were not the same as those in Exp. IX.

Again, verbal and nonverbal sets of stimulus materials made no significant difference (verbal: 44 percent, nonverbal: 47 percent correct), and the same reason used in Exp. IX for this result is given. Again, this variable did interact with other variables. However, these interactions were opposite in two cases and not significant in one case: with transfer set size. The 3-way interaction between stimulus materials, type of talk and transfer set size was again significant, and in all but two cases all differences were of the same order of magnitude and direction as those in Exp. IX. The differences between the two experiments are explored *infra*.

Giving Ss the same number of rote and rule tasks and alternating the verbal and nonverbal tasks interfered with the strategies they used to learn and transfer in the rote and rule tasks. In overall performance they got a total of 29 out of 64 tasks, or about 45 percent of those tasks tried. All Ss got at least 1 task. One S got 7 of the 8 tasks. Median tasks gotten for the group was 4. Although they performed somewhat differently from aphasics in Exp. IX, their overall performance did not suffer.

Again, rule learning was superior to rote learning with aphasics getting 19 percent of the rote tasks and 72 percent of the rule tasks. The interaction of this variable with all others was insignificant.

Further, the larger transfer set was superior to the smaller set, so that aphasics transferred with the 32 stimulus set in 56 percent of the cases and with the 16 stimulus set in only 34 percent of the cases. The interaction of this variable with that of stimulus materials--verbal and nonverbal--was significant, but in the opposite direction from that of Exp. IX. Again the 32 stimulus transfer sets were about equal in difficulty--verbal: 62 percent, nonverbal: 50 percent, but the 16 stimulus sets were harder for verbal (25 percent) than for nonverbal (43 percent) materials. These conflicting results will be easier to account for in the discussion of the 3-way interaction.

The significant 3-way interaction showed differences from Exp IX in only two places: in the rote tasks with a 32 stimulus transfer set, and in the rule tasks with a 16 stimulus transfer set. The two types of tasks were indistinguishable for verbal stimuli, as were the other two types of tasks, but with nonverbal stimuli, the rule-16 tasks showed a very large improvement, while the rote-32 suffered somewhat. Apparently Ss were able to transfer the strategies of coding they used with verbal rule tasks to the nonverbal rule tasks, but application of that same strategy to the rote tasks would result in a lower score. It should be noted that the rote-16 also lowered, but the difference was quite small, even though it was in the right direction.

EXPERIMENT XI

Introduction. The purposes of this study were the same as those in Exps. IX and X, and the design was the same as in Exp. X, except that 8 stimulus sets were used instead of 4 stimulus sets. Also, half of the Ss used in Exp. 10 were the same in this study.

Experimental Design.

a. Number of tasks: 8.

b. Trials permitted: 20.

c. Tasks used: Same as in Exp. X.

d. Number of stimuli: 8.

e. No correct trials given.

f. Transfer set size: 16 or 32 cards.

g. Identification required in transfer.

h. Number of Ss: 8.

i. Number of tasks per session: 2.

j. 4 Ss were the same as in Exp. 10.

Results and Discussion. Except for minor details in the actual percent correct scores, the results of this study are nearly identical with those of Exp. X. There was no difference between verbal and nonverbal materials (31 percent and 44 percent respectively); rule learning was superior (62 percent) to rote learning (12 percent); and 32 stimulus transfer sets gave non-significantly better results (44 percent) than did 15 stimulus sets (31 percent). Specifically, the rote-32 task showed an even more dramatic drop in performance in this study than was shown in Exp. X, and affected the 3-way interaction in the same way.

Although these Ss used 8 stimulus sets, they still achieved 38 percent correct, or 24 of the 64 tasks tried. As was true with the other Exps. using 8 stimulus sets, rote was much worse than rule learning tasks.

EXPERIMENT XII

Introduction. The purposes of this study were to compare aphasics and normals on a set of rote tasks using verbal and nonverbal stimuli, to assess if aphasics could use a specific strategy of learning the stimuli, to assess serial improvement on increasingly difficult tasks, and to examine the difference between mere recognition of the stimuli and identification of response classes of each stimulus.

Experimental Design.

a. Number of tasks: Aphasics: 4, normals: 6.

b. Trials permitted: 10.

c. Tasks used: All tasks were ROTE tasks, with alternating verbal and nonverbal stimuli. Orders of the two types of materials were balanced across Ss.

d. Number of stimuli: 4 and 8 for aphasics; 4, 8, and 16 for normals.

e. No correct trials given.

f. Transfer set size: 32.

g. Identification required for half of Ss; the other half merely sorted out stimuli in learning set without identification.

h. Number of Ss: 8 aphasics and 8 normals.

Results and Discussion. Only 3 tasks were learned by rote by the aphasics and these were all 4-stimulus tasks, 2 using nonverbal stimuli and 1 using verbal stimuli. Therefore, percent correct scores prior to criterion were used for this analysis. Of the 8 Ss, 3 showed serial improvement on the tasks even though the first two tasks used 4 stimuli and the last two used 8 stimuli. There were no significant differences between verbal and nonverbal stimulus materials, however, in all but two cases, verbal stimuli were slightly better than nonverbal.

The arrangement of the stimuli permitted Ss to go from one to the next by noting how many changes in attributes occurred. If an even number of changes occurred, the second stimulus was in the same response class as the first; if an odd number occurred, it was in the opposite class. No stimuli were given at the outset, so Ss had to guess at the first stimulus. If an S was correct or incorrect, he was still told what the correct response class was so that he could use the strategy from the second stimulus on, if he was able to detect it. Ss were not instructed to use the strategy, but were asked following the experiment whether they had used it in any of the tasks. No aphasic had found and used the strategy. Even without the strategy, the 3 tasks that were learned were done in 1, 3, and 7 trials.

The two techniques of transferring to the master set provided a test of the relative difficulty in recognition and in identification. In the first case Ss were required to select from the master set of 32 cards only those that they had used in the learning session. They were not required to select from the master set of 32 cards only those that they had used in the learning session. They were not required to identify their response classes. In the second case, Ss were given the stimulus set used in learning and asked to identify the response classes. Three aphasics were able to recognize the complete set of stimuli correctly from the 32 stimuli. In the 3 cases where the task was learned to criterion and in 10 other cases where criterion was not reached, correct identifications were made. A total of 82 percent correct identifications and 18 percent correct recognitions were achieved by the aphasics. Although Ss were better at the somewhat more difficult task of identification, they had not been able to learn the stimuli to criterion in the 10 trials permitted. It is conjectured that they would have been able to learn prior to the 20 trials that had been given in other tasks in the previous experiments.

Performance by normals was significantly better overall; they achieved 9 correct recognitions with learning, 9 without learning and learned 2 without correctly recognizing the stimuli. They achieved 10 correct identifications with learning, 4 without learning, and learned 5 without correctly identifying the stimuli.

There were 75 percent correct recognitions and 56 percent correct identifications.

Only 4 normal Ss found and used the strategy described to help learn the stimuli. One found it during the first task and the others found it on the third task. One became confused on the seventh task and did not learn the stimuli by the tenth trial.

EXPERIMENT XIII

Introduction. The purposes of this study were to assess the difference between verbal and nonverbal materials and to determine if transfer was possible from simpler to more difficult tasks, and to compare conjunctive, complex disjunctive, and relational rules.

Experimental Design.

a. Number of tasks: 10.

b. Trials permitted: 20.

c. Tasks used: 5 verbal and 5 nonverbal rule tasks counterbalanced in presentation. Rules in order of presentation were: either (C, B, N, and F, FBs, and CB) or (5th, 2nd, 1st and 4th, 1st and 5th (even # of S's), and 2nd and 5th, complex).

d. Number of stimuli: 8.

e. No correct trials given.

f. Transfer set size: 16.

g. Identification required in transfer.

h. Number of Ss: 10.

<u>Results and Discussion</u>. With this group of aphasics, the difference between verbal (60 percent) and nonverbal (70 percent) materials was small and not significant. This result is quite in line with the previous studies reported herein. These overall percent correct scores do not describe the precise nature of the difference between the two kinds of materials which is brought out in their order of presentation.

The rule tasks were ordered according to their expected difficulty based on previous studies. For each kind of stimulus material the nonverbal materials were exactly 10 percent better than their corresponding rules in the verbal materials, except for the simulated relational rule "even # of S's", which was more difficult than its nonverbal equivalent "same form". In the complete ordering of both sets of rules the verbal and nonverbal virtually alternated from first to tenth, with more of the easier rules gotten than the harder rules.

The fact that there was a consistent drop in performance from the simpler to the more difficult rules tasks strongly suggests that the tasks were not merely quantitatively different as judged earlier. The same kinds of strategies that are used in remembering a simple, single variable rule are quite different from those used in remembering a complex two variable relationship, and the difference is upheld across kind of stimulus material. What may be transferred, or actually learned very early in the learning sessions, are the factors which make the S comfortable in the situation: familiarity with the materials, understanding the instructions, etc. There may be one overall influence from ordering the tasks from easy to difficult: Ss may have received much positive reinforcement early and were able to perform better on later tasks.

The actual ordering of the tasks followed almost precisely the predicted ordering by difficulty used to set up the study. From easiest to most difficult the rules were: C, B, 2nd, 5th, FBs, 1st and 4th, N and F, even # of S's, CB and 2nd-5th. Grouping them another way, the easiest rules were single variable, followed by relational, conjunctive, and disjunctive-conjunctive. (It was not possible with these sets of stimuli to construct a pure disjunctive rule without also having a completely correlated conjunctive rule).

In overall performance of these tasks, aphasics achieved quite high scores compared with other studies: 65 out of 100 tasks were gotten, or a total of 65 percent of tasks tried. Scores ranged from 4 to 9 rules gotten out of 10, with the median number of rules gotten for the group being 7. 95 percent of the single variable rules were gotten and only 45 percent of the two variable rules were gotten, including 70 percent correct for the FBs relational rule by itself. These high scores derive from the systematic manner in which the tasks were set up, so that Ss were able to progress from one to the next with a rather high probability of success.

EXPERIMENT XIV

<u>Introduction</u>. The purposes of this study were merely to determine with a group of normals which of the word stimuli could be recognized as real English words and which were considered to be artificial words. These evaluations were then used to define the classes of common and rare words in later studies, starting with Exp. VIII.

Thirty normal Ss who were undergraduate volunteers from the University of Michigan were given a list of all 32 verbal stimuli in their exact order of generation.

The description of how the words were generated and the use to which they would be put was given them. They were asked three questions to be answered about each word: Do you think you have seen this combination of letters before? Do you think it is a real English word?, and, Give a short definition of the word if you can. Ss were able to go through the task in less than 30 minutes.

From these judgments and definitions, the classes of common and rare words were set up as described in the introduction: 14 common and real words, 10 obscure and real words, and 8 words which were artificial. These classes were used to select verbal stimuli in all subsequent studies.

Discussion and Conclusions

The general nature of these rule or concept learning tasks is intellectual. Except for rote learning tasks, which can also involve some of these function, the tasks make use of the processes of abstracting attributes from stimuli and relating these attributes to arbitrary but specific classes of response. The individual must be able to organize the task so that he can reduce the load on memory to an amount within his particular capacity. Attention to specific features of the task so that observations may be transferred to other situations is required. Becuase of the demands of the task, many properties of information processing are required and such aspects as coding, grouping, abstracting, transferring and the like deal with what is ordinarily considered to be linguistic processing. Finally, insofar as it may be said that learning is a process measured by the change in performance toward a criterion as a result of practice, these tasks are learning situations. The specifics of what was learned or what influenced the course of learning is therefore important.

A number of variables were studied in the series of experiments which could have facilitated learning or interfered with it. They could also have been irrelevant, or at least become irrelevant as the task proceeded. The several variables treated in these experiments will be discussed with reference to whether they helped or hindered learning in the set of tasks.

The attributes, of both verbal and nonverbal materials may be considered a variable which, because of preferences which patients brought with them or because of some intrinsic ease with which they could be used, did have some influence. Color, for example, was generally preferred to other attributes, as was the first letter position in the verbal stimuli. This finding was interesting, but it did not fit into the overall interests of the project, so that in later experiments, effort was made to control for the effects of specific attributes.

In the design of the experiments, uncertainty analysis was used to generate stimuli and to set up the system of tasks Ss worked on. Redundancy was a concept used to assess the various tasks and constraints were stringently controlled. These constraints produced tasks which may be described as rote tasks, simple rule tasks and complex rule tasks. The differences between these kinds of tasks along this dimension of constraint are significant and have implications for information processing by aphasics in these tasks. When there is no constraint, Ss are compelled by the nature of the stimulus sets to memorize stimuli by rote in order to learn the correct response classes to which each stimulus belongs. While aphasics were able in many cases to perform this kind of task, they did so with some difficulty and it was not at all guaranteed that they would retain their gains over longer periods of time. When there is constraint in the tasks, rules are generated which relate attributes to one another and to specific response classes. Learning the stimuli in such tasks is much easier for aphasics than learning by rote. However, if constraint is higher than some optimum amount, more complex rules are generated, and again the task becomes more difficult for aphasics. The simplest way of putting this result is in terms of the amount of memory load it provides. At both extremes of constraint, complex verbal structures are necessary for the description of the stimuli, but in the middle range, simpler verbalizations are able to be used. Another way of lowering the memory load or making the descriptions simpler is to lower the absolute number of stimuli which must be learned by rote. This interaction was observed and it was possible to design rote tasks which were as easy as rule tasks. Another interaction occurs when different kinds of stimulus material are used. So that without large amounts of practice, a rote task which, under other conditions, would be as easy as a rule task, may be more difficult. This resulted from the verbal stimuli used and it was conjectured that the simplest way of distinguishing these stimuli--by pronunciation--was apparently not available to all of the aphasics and hence could not be used by them. Thus the rote tasks even with very few stimuli were more difficult than the rule tasks.

The actual pattern of constraints is what gives us the difference between simple and complex rules. Here again, significant differences are obtainable between these two kinds of rules, and much of this effect is attributable to the complexity of linguistic coding required merely to be able to state the rule. Although performance on tasks using this variable could be manipulated by the introduction of other variables, when their effects were extracted, it was found that there were no interactions and that pattern of constraints had a pure effect with the one exception of a structure called "relational". A relational rule is one which permits Ss to reduce a complex rule to a much simpler statement of that rule, such as reducing the statement, "circular form and circular border of triangular form and triangular border" to the statement, "same shape". This type of restatement was typically used where it was possible to do so, but there were few instances in which it could be used, just as there are in real life.

The other large variable studied, that of verbal and nonverbal stimuli, showed little overall effects. Within the verbal level, there was also the subvariable of common and rare words, which again showed little overall effect. Although it was expected that these variables might have some effects because of the aphasics' peculiar language difficulties, a closer look at the tasks shows that other factors were far more important. The ability to organize and select materials, the ability to code them properly into classes and remember that coding, and the ability to abstract certain features and to reject certain others are more important in these tasks where the significant aspects do not depend on the language properties of the stimuli. This finding is in substantial agreement with Weinstein (1967) and with Weisenberg, et al (1936). Further, the complexity of these tasks far overrides their specific logical or linguistic features, so that although both of these features may be shown to be failing, this result may simply be a matter of limited capacity and inability to organize what abilities are remaining, as Furth and Youniss (1968) have pointed out.

Finally, the specific experimental design included a competing simple task presented to Ss along with the more complex and central task of learning rules. In agreement with the descriptions of "perceptual adhesiveness and reduction of plasticity", given by Alajouanine and Lhermitte (1962) to behavior by brain-damaged individuals, our group of aphasics also showed that the simple task could interfere with the more complex task, but to present it in such a way that the probability of success is higher than it might be otherwise.

In general, the relationships between performance on these rote and rule learning tasks and IQ, fluency and severity were inconsistent. Correlations varied from -.54 to +.58, when patients were compared within the small experimental groups, and although some of the higher ones were significant, their scattering of magnitude was so great as to limit their usefulness in prediction. However, relationships with the Raven Matrices were much more consistent using these small groups, even though fee of them were sufficiently high to reach statistical significance. We may conclude that the most significant thing about aphasia is not a failure of intellectual functioning, but the general heterogeneity of behavior which is produced as a result of the insult, as the signal feature.

Although the project was not designed specifically to compare aphasics with normals in these tasks, some normal control groups were used as station points along the way. Some comments about these two groups are in order. Aphasics were affected in many of the same ways that normals were affected by the various variables in these experiments, even though aphasics typically performed poorer on the tasks. In short, there were few interactions between Ss as a variable and the other experimental variables used. However, although aphasics and normals are alike in many respects, there are three important and significant differences between the two groups.

Aphasics showed a general lowering of capacity in dealing with numbers of items, however these items were classified. Their ability to sort out and to attend to individual items and then to replace them into their parent categories was impaired. Second, their ability to shift from one task to another and to use a different set of stimuli, ideas, rules or strategies was impaired. They were more affected by interfering tasks than were normals, and chose to work simpler tasks when their job was to work more difficult tasks. This behavior is quite rational and shows good adjustment given that their capacity to engage in a task has been reduced. However, by manipulating the experimental conditions, these kinds of interferences may be eliminated and more complex tasks may be performed. Finally, aphasics typically take much more time to perform a task than do normals. Although they were not under time pressure in the rote and rule learning experiments, it is conjectured that unless the rewards for rapid work are very high, aphasics will seek accuracy as their criterion in almost any task type rather than work for the dual criterion of speed and accuracy. These three factors are inter-related in complex ways and they amount here to little more than extra-curricular observations since they were not the central issues that were studied. However, their observation lays the groundwork for future explorations on the nature of aphasia and the resulting behavior which have implications for both theory and therapy.

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